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Determinants of Duration of Disability and Return-to-Work After Work-Related Injury and Illness: Challenges for Future Research

Niklas Krause, MD, MPH, PhD,[1,2,6*] John W. Frank, MD, CCFP, MSc, FRCP (C),[1,3,4,5] Lisa K. Dasinger, PhD,[6] Terry J. Sullivan PhD,[4,7] and Sandra J. Sinclair, Dip P & OT, MSc[4]

Background *The purpose of this review was to identify critical data and research needs in addressing the following question: What are the primary factors that affect the time lost from work, return-to-work (RTW), subsequent unemployment, and changes in occupation after disabling illness or injury?*

Methods *Review of the literature to identify research challenges originating from the multitude of disciplines, data sources, outcome measures, and methodological and analytical problems.*

Results *About 100 different determinants of RTW outcomes were identified. Their impact varies across different phases of the disablement process. Recommendations are provided for addressing five selected research challenges.*

Conclusions *Interdisciplinary research needs to develop a comprehensive conceptual framework. Priority should be given to studies on specific domains of risk factors meeting five selection criteria: amenability to change; relevance to users of research; generalizability across health conditions, disability phases, and settings; "degree of promise" as derived from qualitative exploratory studies; and capacity to improve measurement instruments. Combining qualitative and quantitative research methods is necessary to bridge existing knowledge gaps.* Am. J. Ind. Med. 40:464–484, 2001.

KEY WORDS: review; occupational disability; job retention; labor force participation; re-employment; vocational rehabilitation; predictors; prevention; research policy

INTRODUCTION

Return-to-work (RTW) outcomes and duration of disability are increasingly used as performance measures for health care providers, vocational rehabilitation services, and workers' compensation insurers. Frequency and duration of work disability are also indicators of the economic and social impact of occupational injury and illness. RTW outcomes are relevant for both work-related and non-work-related injuries and illnesses, and medical studies often do

[1] School of Public Health, Division of Epidemiology, University of California, Berkeley, California
[2] School of Medicine, Division of Occupational and Environmental Medicine, University of California, San Francisco, California
[3] Department of Public Health Sciences, University of Toronto, Toronto, Ontario, Canada
[4] Institute for Work and Health, Toronto, Ontario, Canada
[5] Population Health Program, Canadian Institute for Advanced Research
[6] Public Health Institute, Berkeley, California
[7] Department of Health Administration, University of Toronto, Toronto, Ontario, Canada.
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*Correspondence to: Niklas Krause, School of Public Health, Center for Occupational & Environmental Health, University of California at Berkeley, 745 University Hall, Berkeley, CA 94720-7360. E-mail: nkrause@uclink4.berkeley.edu

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not distinguish between the two. Understanding the causes and predictors of work disability and RTW outcomes is a prerequisite for the development of effective disability prevention strategies.

The authors were invited by NIOSH to evaluate the current state of knowledge regarding the measurement and determinants of return-to-work outcomes after disabling illness or injury and to identify critical data and research needs. Limited resources and the complexity of the question did not permit an exhaustive review of all the relevant literature necessary to truly represent the contributions made from researchers in the many relevant disciplines. Instead, we chose to address a *selection of key issues* which we have identified in the course of our own extensive research experience in this field. Therefore, our literature review is not intended to be systematic or complete but is instead illustrative of these key issues.

The paper is organized in five sections, each discussing a specific challenge for future research. Recommendations for meeting these challenges are provided in each section and are summarized at the end of the manuscript.

CHALLENGES FOR FUTURE RESEARCH

First Challenge: Definition, Choice, and Measurement of Outcomes

Purpose of RTW outcome measures. In principle, measures of duration of disability and RTW outcomes serve multiple functions. First, they are indicators of the overall burden of occupational disability on society. Second, they are used to determine the burden of disability shouldered by specific groups, e.g., injured workers themselves, their families, their local communities, employers, industries, and economic sectors. Third, they are used to evaluate the effectiveness and efficiency of intervention programs and policies aimed at helping injured workers maintain their occupational roles, whether offered by workers' compensation, group health, private and public disability insurance carriers, disability management or vocational rehabilitation services, or legislation such as the Americans with Disabilities Act. Finally, they are used to measure the impacts of such interventions on societal costs of injuries and illnesses and on specific groups in society.

Definitions of work disability and RTW outcomes. A useful definition of disability for studying the impact of occupational injury and illness would help answer the following key questions: Who is disabled? Is the disability work-related? How severe is the disability? When was the onset? How long does it last? The Americans with Disabilities Act defines disability as a "physical or mental impairment that substantially limits one or more major life activities, a record of such an impairment, or being regarded as having such an impairment." This definition of disability is much broader than definitions based merely on the receipt of disability benefits, the proportion of pre-injury wages earned post-injury, or on a presumably objective set of medical criteria such as the AMA *impairment* guidelines [Cocchiarilla and Andersson, 2001] that do not explicitly incorporate information about the individual's social environment or the actual demands it makes on the affected person.

The term "RTW outcomes" refers to a variety of related concepts and definitions of vocational outcomes after disabling injury or illness and is used to describe the duration or extent of an inability to work due to impaired health or functional limitations. Duration of work disability can be defined (1) cumulatively, as the duration of all days lost from work beginning with the date of injury, (2) categorically (e.g., RTW ever yes/no; working at time $\times$ yes/no), or (3) continuously, as time-to-RTW (e.g., calendar time from date of injury to date of first RTW, or as sustained RTW, to the end of the last missed work day after a series of disability episodes) [Krause, 1999]. RTW may be qualified as return to the pre-injury employer or the pre-injury job, implying a comparison with the pre-injury situation. Measurements may be based on actual RTW, ability to RTW, time receiving workers' compensation wage replacement benefits, earnings data, the presence of a job offer, sick leave which is not paid for by workers' compensation but is sometimes a result of occupational injury or illness, or various sequential combinations of different RTW outcomes ("RTW patterns") with or without gaps in disability. Several types of job separation may be used as indirect measures of RTW outcomes, including involuntary termination, unemployment, or retirement. The need for clear definitions of RTW outcomes and the pros and cons of some commonly used outcomes are discussed in the next two sections.

Stakeholder perspectives on choice of outcome measures. It needs to be acknowledged that each stakeholder in the RTW process has its own concept of the most appropriate outcome measure that captures the "key benefit" of successful RTW [Melles et al., 1995]. In some cases, the RTW outcome is directly and routinely measured (e.g., workers' compensation costs, end of disability benefit payments). In other instances, the outcome is only indirectly related to RTW and is not routinely measured (e.g., improvement in pain, function, and quality of life). Limiting a research agenda to traditional RTW outcomes (such as duration of temporary disability benefits) would reflect a limited perspective bound to underestimate duration of work disability and total burden [Galizzi and Boden, 1996; Jette and Jette, 1996; Dasinger et al., 1999]. More inclusive measures of the *direct* impact of work disability, including

all indemnity benefit payments, and legal and medical costs, still represent only a fraction of the total actual economic burden of occupational injury and illness. *Indirect* costs borne by the employer, including productivity losses, and employee substitution costs etc., have been estimated to be at least 2–4 times direct workers' compensation costs [Snook and Webster, 1987; Snook, 1988]. Including wage-loss data helps capture even more of the economic losses suffered by the injured worker [Peterson et al., 1997; Reville, 1999]. It is, of course, impossible to adequately describe in financial terms the burden of pain and suffering and reduced quality of life, and their full impact on families, coworkers, communities, and society at large. A recent appraisal estimated that all workers' compensation costs (about 60 billion dollars in 1992) represent only about 40% of the total costs associated with occupational injury and illness in the U.S. [Leigh et al., 1997]. Although RTW outcomes cannot completely reflect the impact of occupational injury and illness in terms of work-related disability, they are important in their own right and a necessary component of any more complete assessment.

Operationalization of RTW outcomes and data sources. There are many methods of operationalizing the broader definition of disability [LaPlante,1991], but in most research projects the selection depends on the availability of data [Daly and Bound, 1996]. The main data sources used in disability research are: *(a) routinely collected* data from (1) representative population surveys such as the National Health and Nutrition Examination (NHANES), National Health Interview Survey (NHIS), and the recently available Health and Retirement Study (HRS), (2) surveys of employers such as the Survey of Occupational Injuries and Illnesses, produced annually by the Bureau of Labor Statistics (BLS), (3) unemployment insurance data from provincial/state-level agencies, and (4) administrative data from public and private health, disability, and workers' compensation insurance carriers, and *(b) original data collected for specific research purposes* in clinical studies, epidemiological surveys, and intervention studies.

The burden of disability, and more specifically, the duration of work disability or "time to RTW" assessed from these data sources, vary by several multiples, according to data source [Oleinick et al., 1993; Peterson et al., 1997; Dasinger et al., 1999], and the outcome measure selected within the same data source [Rossignol et al., 1992; Butler et al., 1995; Dasinger et al., 1999; Krause et al., 1999]. For example, data based on OSHA 200 logs from employers in the BLS Survey of Occupational Injuries and Illnesses were found to underestimate the number of missed workdays by a factor of 4.8–8.5 compared to the compensated days of work disability recorded in the Michigan Comprehensive Compensable Injury and Illness Database [Oleinick et al., 1993], and compared to other administrative data from workers' compensation insurers [Hashemi et al., 1997; 1998]. This is largely due to the survey method used for the BLS statistics; time lost beyond the end of the calendar year is not reported. For the most prevalent conditions, the majority of disability days is accrued by cases with chronic disability. For example, in the case of LBP, 60% of the total number of disability days is accrued after 1 year of disability [Hashemi et al., 1997]; the corresponding proportion for upper extremity musculoskeletal disorders is 47% [Hashemi et al., 1998]. Moreover, not all workers are covered by workers' compensation insurance, many covered injuries are not reported, and many costs to society beyond those paid by workers' compensation exist [Leigh et al., 1997].

Estimates of work disability derived from administrative workers' compensation databases can differ substantially, depending on the operationalizations of outcomes. Recently, 11 operationalizations of compensated work disability were compared using Kaplan-Meier estimates in a 3-year cohort of 433 workers' compensation LBP claimants followed up for an average of 3.5 years [Dasinger et al., 1999; Krause et al., 1999]. The estimated mean duration of work disability was 60 days if measured until the end of the first episode of temporary disability (TD) benefits, 75 days if all TD episodes were counted, and 200 days if all types of wage replacement benefits were measured (including permanent disability). When administrative outcome measures were compared to self-reported time-to-RTW, the number of lost work days was on average between 142–334 days more than that estimated by the administrative database alone [Dasinger et al., 1999] (See Fig. 1).

Recent econometric studies of wage loss after injury indicate that real wage loss is likely to be considerably greater than the difference between pre-injury earnings and indemnity benefits actually paid during work disability. Comparing the income of injured workers to that of employer- and pre-injury-wage-matched controls, Peterson and coworkers reported that only about 40–50% of wage loss after injury is compensated in California [Peterson et al., 1997; Reville, 1999]. This approach closes an important gap in the measurement of wage loss.

In conclusion, while any of the aforementioned databases may provide RTW outcome data, they are not of equal value in determining the actual burden of disability associated with occupational injuries and illnesses. Strengths and weaknesses of various data sources can be highlighted as follows. National surveys employ a broader, nonlegal definition of disability (activity limitations) but are usually limited to an insufficient follow-up period of 12 months (except the Health and Retirement Study).

Unemployment insurance data have sufficient follow-up, but they exclude the uninsured, may provide only quarterly wage data, the interpretation of lack of earnings is ambiguous, and the link with disability can only be

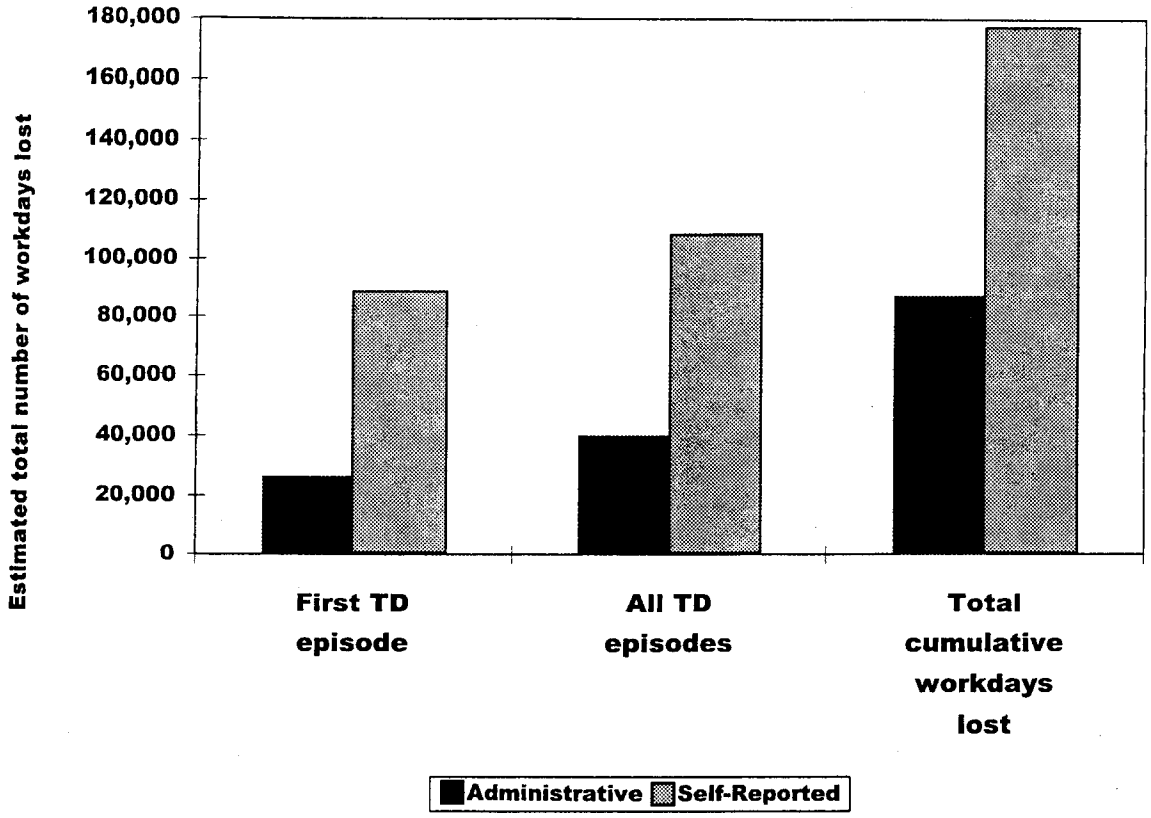

FIGURE 1. Estimated total number of workdays lost for administrative vs. self-reported RTW outcomes. 1994-1996 California LBP Claimant Cohort, N = 433 (adapted from Dasinger et al. 1999)

established with a matched control population of workers not injured. Self-report data may include multiple and comprehensive outcome definitions, but with increasing length of follow-up, attrition problems, responder bias, and recall errors increase.

For these reasons, future research should include both self-reported and administrative data on disability and RTW, in order to insure a comprehensive assessment of work-related disability and to provide the means to assess the magnitude of reporting biases from any one data source. If workers' compensation data are used, several outcome measures may need to be reported [Krause et al., 1999]. The outcomes time-to-the-end-of-*first*-temporary-disability-episode and time-to-*first*-RTW have very limited value and should always be complemented by measures more inclusive of recurrences [Butler et al., 1995; Galizzi and Boden, 1996; Dasinger et al., 1999; Krause et al., 1999]. Even *cumulative* measures of time-on-*temporary*-disability are insufficient for capturing the important effects of long-term disability beyond one year. In jurisdictions providing *permanent* disability benefits and other wage replacement benefits, researchers should also provide the total number of effectively compensated days as one of their outcome measures. This measure is easily calculated from claims data and includes indemnity benefit payments during temporary disability, vocational rehabilitation, and permanent disability [Oleinick et al., 1993; Dasinger et al., 1999; Krause et al., 1999].

Complementary functional and quality-of-life outcomes. It is beyond the scope of this paper to discuss complementary functional and quality-of-life outcomes in any detail. Health-economic methods for evaluating health effects per se, such as pain, and reduction in functional status and quality-of-life, both before and after RTW, are available. However, these have been little used in RTW research [Sinclair and Burton, 1994]. Unfortunately, most available data bases provide no information on functional disability after RTW. Given the recurrent nature of many disabilities and the problem of recall bias, multiple follow-up surveys and/or examinations are necessary at staged intervals over several years. One ongoing inception cohort study in Canada employing such a design has already provided interesting new insights and more results are expected shortly [Hogg-Johnson et al., 1998].

Physicians' impairment ratings of injured workers can also be used to capture the extent of functional limitation, and they may be available in some databases. The informed public, however, not just injured workers, report higher levels of disability for standardized case vignettes than is

indicated by physician ratings based on AMA impairment guidelines [Sinclair and Burton, 1994].

It seems important that all stakeholders participate in the development of complementary measures of RTW outcomes and that research cover multiple outcomes in order to serve the full range of stakeholders. Duration of work disability should always be included, because it is a salient outcome for the majority of stakeholders. Other direct and indirect costs (borne by the employee, employer, and others) need to be considered in more comprehensive analyses. Examples include medical and legal costs, costs for restructuring production, worker replacement and training costs, and productivity losses.

In conclusion, it is recommended that future studies always include at least one functional/quality-of-life component, and that intervention studies be designed a priori to include a comprehensive cost-effectiveness and cost-benefit analysis. For example, it has been shown consistently that modified work programs increase cumulative RTW rates by a factor of about two and cut disability days in half, but only 3 out of 13 high-quality studies on RTW attempted a rudimentary health-economic analysis, demonstrating feasibility, but falling short of a comprehensive cost-benefit analysis [Krause et al., 1998a]. None of the studies evaluated functional or quality-of-life outcomes after RTW. Obtaining both economic and functional outcome information addresses the immediate concerns of employers regarding the costs of modified work programs, and of employees and their physicians regarding the risk of recurrence or exacerbation of the health condition if work is resumed "too early."

Second Challenge: Multiple Health Conditions, Multiple Disciplines, Multiple Literatures, and Lack of an Overarching Conceptual Framework

A systematic review of the RTW literature is complicated because it needs to cover a wide range of diseases and conditions with varying natural histories, requiring different treatment and rehabilitation strategies, and probably exhibiting somewhat different prognostic risk factor profiles. Also, determinants of RTW may vary by jurisdictional differences in compensation, disability and unemployment insurance, and in social welfare and retirement systems. Moreover, much of the current understanding of the return-to-work process is based on studies of limited scope and often low methodological quality. Few prospective studies are available that encompass the requisite range of variables. Systematic reviews of the literature are limited to particular aspects of the problem (e.g., health care factors or workplace factors) and are often inconclusive. Evidence is scattered across the writings of many diverse disciplines including epidemiology, medicine, psychology, sociology, anthropology, economics, business administratration, public policy, and unpublished reports from insurance carriers or state agencies. Potentially valid bibliographic search subjects include absenteeism, accidents, aging, Americans with Disability Act, compensation, disability, health services, injury, job retention, labor force participation, re-employment, return-to-work, quality of life, medical and vocational rehabilitation, social welfare and retirement policies, public policy, and a wide variety of medical diagnoses.

The enormity of the task may be illustrated by a recent systematic review of the literature on the effectiveness of modified work programs. A search by 8 keywords (return, modified, alternative, injury, disability, rehabilitation, outcome, and compensation) yielded over 30,000 citations within three electronic databases (Medline, PsychInfo, and American Business Index). A more limited search strategy still yielded 1,543 journal article titles, 939 abstracts, and 196 full articles, of which 29 relevant articles were of sufficient methodological quality to warrant a formal evaluation [Krause et al., 1997a, 1998a]. The difficulty of such a comprehensive search is compounded by the challenge of applying consistent criteria for study evaluation and synthesizing the results across different outcome measures. On the other hand, the apparent effectiveness of modified work programs across a heterogeneity of diseases, research disciplines, study designs, and outcome measures makes the concept of modified work all the more generalizable. The study of RTW in general may also reveal common determinants across diseases or outcome definitions.

A related challenge is the development of a comprehensive theory of the disablement and return to work process, requiring the understanding and integration of rather different theories from the various relevant disciplines. This topic is beyond the scope of this review. It has been our experience, in common with the view of other epidemiologists concerning their discipline in general [Krieger, 1994], that the entire RTW field is undertheorized. While there are some excellent general theories of disablement [Nagi, 1965; Stone, 1984; Verbrugge and Jette, 1994] which emphasize the importance of the social environment, these make only passing reference to the workplace specifically or to the various stakeholders in the RTW process. Consequently, this review focuses on the empirical knowledge base, with only limited references to theoretical considerations. Nevertheless, the development of an explicit conceptual framework for the RTW process would help unify the many streams of research in this field. Recent suggestions for a more comprehensive conceptualization of occupational health, disability, and RTW may serve as a starting point [Krause and Ragland, 1994; Jette and Jette, 1996].

Third Challenge: Multifactorial Nature of Disability and RTW. Work disability and RTW are not uniquely biome-

dical outcomes, but are processes influenced by a variety of social, psychological, and economic factors not necessarily specific to the underlying or precipitating injury or illness [Pope and Tarlov, 1991; Krause and Ragland, 1994; Verbrugge and Jette, 1994; Lawrence and Jette, 1996] Putative determinants of RTW include characteristics of the injured worker, the medical care system and vocational rehabilitation, physical and psychosocial job characteristics, interventions in the workplace, the employer, the disability insurance system (especially workers' compensation), and societal factors such as discrimination, the legal framework, and labor market and macroeconomic characteristics. Only a few systematic reviews covering some of these domains are available, a comprehensive review should be an integral part of future research activities.

The objective of this selective review is to provide the context for and evidence to support the suggested framework for developing research priorities. This review of the literature was limited to empirical studies and reviews published in English since 1970 of which the authors were aware. Most of our current knowledge arises from the literature on musculoskeletal injuries (predominantly low back pain), which are responsible for the majority of work disability and associated costs in industrialized countries today [Leigh et al., 1997]. Chronic disabling illnesses, such as occupational skin, pulmonary, or cardiovascular diseases, the latter not widely recognized as work-related [Schnall et al., 2000], deserve special attention in a separate paper focusing on chronic illnesses and RTW. Although this is not explicitly addressed in this paper, we believe that there is an overlap in conceptual issues studying disability due to injuries and illnesses, and that similar research challenges emerge for both kinds of work-related conditions. Chronic diseases without evidence for occupational causation may differ from these work-related conditions regarding the associated determinants of RTW. In this review, studies regarding non-work-related conditions (e.g., rheumatoid arthritis) are occasionally cited, especially when the relevant barrier to RTW has not yet been investigated for any work-related condition.

Based on this approach to the literature, a preliminary list of core risk factors for prolonged disability and delayed RTW is provided in Tables I through VII. The list was compiled from several relevant reviews, largely from the well developed field of low back pain research [Frymoyer and Cats-Baril, 1987; Polatin, 1991; Frymoyer, 1992; Frank et al., 1996; van der Weide et al., 1997; Krause et al., 1997a, Sinclair et al., 1998; 1998a] and from the economics literature [Gardner, 1989; Galizzi and Boden, 1996]. The quality of the evidence has generally not been evaluated, although some reviews made useful attempts in this direction [Frank et al., 1996; Galizzi and Boden, 1996; Krause et al., 1998a]. The recent narrative review by Sinclair and coworkers covers most relevant areas and forms the primary basis and organization for these tables [Sinclair et al., 1998]. Some studies using outcomes such as absenteeism, job retention, employer change, disability retirement, and unemployment were added to their list, since predictors of these outcomes are conceptually related to predictors of RTW outcomes. Where available, higher quality studies and newer references, including unpublished material, are supplemented from the present authors' personal reference libraries.

The sequence of the tables follows a hierarchical organization from "individual level" factors to "societal level" factors. The list of determinants of RTW outcomes covers individual worker characteristics (Table I), injury descriptors (Table II), medical and vocational rehabilitation (Table III), job task level physical and psychosocial job characteristics (Table IV), organizational level employer factors (Table V), employer- or insurer-based disability prevention programs (Table VI), and societal level legislative, social policy, and macroeconomic factors (Table VII).

The purpose of listing these risk factors here is to show the breadth of risk factors identified in the current literature. Few studies have measured factors spanning several of the many domains, so it is not known which factors represent "independent" contributors as opposed to intermediary variables or confounders of other variables. Interaction between the many variables is likely but most studies did not examine this. Because of these and other limitations, effect-sizes or other standard parameters that would be required for ranking the quality and relevance of the different risk factors are not reported. However, studies are grouped by the direction of the observed effects (prolonged or shortened disability) or their disability phase-specificity. Phase-specific risk factors change the direction and/or the size of the effect over the course of the disabling condition. Studies showing no effect are listed separately for each risk factor. This organization of the tables was chosen to highlight inconsistencies in the knowledge base indicating possible areas for further scientific inquiry.

Table I lists individual level worker characteristics associated with RTW outcomes, including sociodemographic factors, psychological factors, attitudes, beliefs, expectations, and clinical measures of health and functioning. With the exception of education, income, and beliefs or expectations regarding RTW, most of these individual risk factors are not amenable to change through any intervention programs. These factors may be useful in predicting RTW outcome and identifying high risk groups, but disability prevention strategies need to be informed by more modifiable risk factors.

Table II lists characteristics of the injury or illness, including affected body part, severity, and medico-legal descriptors of the injury. Although medical diagnosis and compensability may be useful in describing injuries at an

TABLE I. Individual Level Worker Characteristics Predicting Duration of Work Disability

Variable	Effect on work disability
Sociodemographic factors	
Older age	Prolonged [Bigos et al., 1986; Tate, 1992b; Cheadle et al., 1994; Abenhaim et al., 1995; Galizzi and Boden, 1996; Infante-Rivard and Lortie 1996; Hlatky et al., 1998, for age group < 60; MacKenzie et al., 1998; Dasinger et al., 2000; Karoff et al., 2000; McIntosh et al., 2000; van der Giezen et al., 2000; Krause et al., 2001]
	Shortened [Hlatky et al., 1998, for age group 60–64]
	Phase-specific [Dasinger et al., 2000; Research and Oversight Council on Workers' Compensation, 1997]
Female gender	Prolonged [Bigos et al., 1986; Yelin, 1986; Cheadle et al., 1994; Kemmlert and Lundholm, 1994]
	Shortened [Hlatky et al., 1998]
	No effect [Lanier and Stockton 1988; Rossignol et al., 1992; Coste et al., 1994; Galizzi and Boden, 1996; Dasinger et al., 2000; Krause et al., 2001]
Marital status single (female) or divorced/widowed (male)	Prolonged [Volinn et al., 1991; Cheadle et al., 1994]
	No effect [Marklund,1995] Phase-specific [Hess et al., 2000]
Having dependents	Prolonged [Cheadle et al., 1994]
Being a breadwinner	Shortened [van der Giezen et al., 2000]
Lower education/income	Prolonged [Danchin et al., 1982a; Deyo and Tsui-Wu 1987; Frymoyer and Cats-Baril, 1987; Volinn et al., 1991; Tate, 1992a; Marklund 1995; Straaton et al., 1995; Daly and Bound, 1996; MacKenzie et al., 1998]
	Phase-specific [Galizzi and Boden, 1996]
Blue collar occupation	Prolonged [Cheadle et al., 1994; Krause et al., 1997b]
	Phase-specific [Andersson et al., 1983; MacKenzie et al., 1998]
Unemployed pre-injury	Prolonged [Danchin et al., 1982a; Burnham et al., 1996; Krause et al., 1997b]
Unemployed post-injury	Prolonged [Straaton et al., 1995]
Unemployed family members	Shortened [Krause et al., 1997b]
Spouse on disability retirement	Prolonged [Marklund, 1995]
Working family members	Prolonged [Krause et al., 1997b]
Fewer years with employer	Prolonged [Tate, 1992a; Galizzi and Boden, 1996; Dasinger et al., 2000; Høgelund 2000; Krause et al., 2001]
More jobs since age 20	Prolonged [Høgelund, 2000]
Union membership	No effect [Dasinger et al., 2000; Krause et al., 2001]
Poverty	Prolonged [MacKenzie et al., 1998]
Beneficiary of Social Disability Insurance	Prolonged [Straaton et al., 1995]
Psychological factors	
Hypochondriasis and Hysteria (scales 1 and 3 of MMPI)	Prolonged [Gallagher et al., 1989; Lacroix et al., 1990]
	No effect [Lacroix et al., 1990]
History of anxiety or depression	Prolonged [Lanier and Stockton 1988; Claussen et al., 1993]
Mental health limitations (SF36)	Prolonged (Netherlands) [Høgelund, 2000]
	No effect (Denmark) [Høgelund, 2000]
History of childhood abuse	Prolonged [McMahon et al., 1997]
Attitudes and beliefs	
Individual prediction of continued disability	Prolonged [Clancy et al., 1984; Frymoyer and Cats-Baril, 1987; Stansfeld et al., 1994; Vendrig, 1999; Høgelund, 2000]
Perception of inability to change job	Prolonged [Gallagher et al., 1989]
Understanding of medical condition	Shortened [Lacroix et al., 1990]
Health Behaviors	
Lifelong & current heavy smoking	Prolonged [Høgelund,2000]
Clinical Measures	
Poor general health	Prolonged [Biering-Sorensen and Thomsen, 1986; Yelin 1986; Astrand, 1987; Bound, 1991; Claussen et al., 1993; Krause et al., 1997b; van der Giezen et al., 2000]

TABLE I. *Continued*

Variable	Effect on work disability
Comorbidity	No effect (first RTW) [Høgelund, 2000]
	Prolonged (sustained RTW) [Høgelund, 2000]
Psychosomatic complaints	Prolonged [Frymoyer and Cats-Baril, 1987; Deyo and Diehl, 1988; Vendrig, 1999]
Non-organic signs (Waddel)	No effect [Vendrig, 1999]
	Phase-specific [Lancourt and Kettelhut,1992; McIntosh et al., 2000]
Activity limitations	Prolonged [Yelin 1989; Galizzi and Boden, 1996]
Impairment (by AMA guidelines)	Prolonged [MacKenzie et al., 1998]
Previous episodes of pain	Prolonged [Coste et al., 1994]
Previous back injury	Shortened [McIntosh et al., 2000]
	Phase-specific [Dasinger et al., 2000; Krause et al., 2001]
Previous back surgery	Prolonged [Vendrig, 1999]
Decline in health	Prolonged [Bound et al., 1998]

individual level, it is important to recognize that these factors are influenced by societal level conventions and policies.

Table III lists medical and vocational rehabilitation intervention programs by three disability phases in terms of eligibility, defined as acute (<30 days of disability), subacute (30–90 days), and chronic (>90 days). This section does not include the many studies on effective treatment of particular conditions [e.g., Spitzer et al., 1987; van der Weide et al., 1997]. Improved medical treatment may be an important factor for time to RTW and prevention of recurrences, especially where common treatment patterns are suboptimal, as in the case of LBP [Frank et al., 1998]. On the other hand, a randomized controlled community intervention trial in Sherbrooke, Canada, showed that the effect of medical interventions may be explained by concurrent ergonomic work modifications [Loisel et al., 1997]. For workers with severe mental illness, supported employment, i.e., on the job support by trained employment specialists, appears to be an alternative to traditional prevocational training to facilitate competitive employment in work settings integrated into a community's economy [Crowther et al., 2001].

Table IV lists job level task and work organizational chracteristics which constitute barriers for RTW. Only a few studies investigated the phase-specificity of these risk factors, and all of them for duration of disability after low back pain. Both high physical and psychological job demands appear as barriers to RTW during the acute and subacute/chronic disability phases, while supervisor support, low job control, particularly low control over the work and rest schedule, seem to predict duration of disability specifically during the subacute/chronic disability phase [Krause et al., 2001]. Interestingly, some of the same physical and organizational job factors that constitute barriers for RTW of disabled workers also increase the risk

TABLE II. Injury Descriptors Predicting Duration of Work Disability

Variable	Effect on Work Disability
Disease category (specific medical diagnosis)	[Lanier and Stockton, 1988; Johnson and Ondrich, 1990; Chirikos 1993; Cheadle et al., 1994; Abenhaim et al., 1995; Marklund 1995; Cole and Hudak, 1996; Infante-Rivard and Lortie, 1996; Krause et al., 1997b; van der Weide et al., 1999a]
Injury or illness severity (based on medical diagnosis)	Prolonged [Maeland and Havik, 1986]
	Phase-specific prolonged: [Dasinger et al., 2000; Krause et al., 2001]
Body part injured	Phase-specific [Galizzi and Boden, 1996]
Compensability	Prolonged [Greenough and Fraser 1989; Coste et al., 1994; Katz et al., 1997]
	Phase-specific [MacKenzie et al., 1998]
Longer time off work	Prolonged [Gallagher et al., 1989; Frymoyer, 1992; Rossignol et al., 1992; Marklund, 1995]
Pain intensity or radiation	Prolonged: [Bergquist and Larsson 1977; Andersson et al., 1983; Coste et al., 1994; van der Weide et al., 1999a; Høgelund, 2000; van der Giezen et al., 2000]
	Phase-specific [McIntosh et al., 2000]

TABLE III. Medical and Vocational Rehabilitation Interventions Predicting Duration of Work Disability

Variable	Effect on work disability
Acute disability phase	
Back education	Shortened [Bergquist and Larsson, 1977]
	No effect [Cohen et al., 1994; Koes et al., 1994]
Back education and exercise	Shortened [Malmivaara et al., 1995]
	No effect [Berwick et al., 1989; Faas et al., 1995]
Medical case management	Shortened [Wiesel et al., 1984, 1994; van der Weide et al., 1999b]
Physician–patient communication about job	Shortened (phase-specific) [Dasinger et al., 2001]
Physician recommendation of RTW	No effect [Hall et al., 1994, in contrast to authors' claim; Dasinger et al., 2001]
Subacute disability phase	
Early activation with graduated sub-maximal exercise, operant conditioning, education, and worksite visit by physical therapist or similar program	Shortened [Lindström et al., 1992; Linton et al., 1993]
Medical case management	Shortened [Indahl et al., 1995; van der Weide et al., 1999b]
	No effect [Loisel et al., 1997]
Physician–patient communication about job	No effect [Dasinger et al., 2001]
Physician recommendation of RTW	Shortened (phase-specific) [Dasinger et al., 2001]
	No effect [Hall et al., 1994, in contrast to authors' claim]
Chronic disability phase	
Multimodal functional restoration	Shortened [Mayer et al., 1987; Hazard et al., 1989; Cutler et al., 1994; Bendix et al., 1997; Feuerstein et al., 1993]
	No effect: [Mellin et al., 1993]
Vocational rehabilitation program of counseling to establish/monitor goals plus use of social service resources	Shortened [Davey et al., 1993]
Supported employment	Shortened [Crowther et al., 2001]

of work disability by causing the underlying condition or the report of an injury in the first place [Krause et al., 1997b; Krause et al., 1998b]. Table IV is limited to those factors that influence duration of work disability; it does not include the large body of literature on work-related determinants of health in general [Karvonen and Mikheer, 1986], which can be seen as contributing to work-related disability by causing the injury or illness underlying the observed disability.

Table V lists organizational level employer characteristics predicting duration of disability. Only a few and relatively recent studies have identified global measures of organizational level characteristics such as size and type of employer, unionization, or particular organizational cultures. In terms of the direction of the observed associations, findings appear contradictory on most of these variables. This may be typical for an area of research which is still in its infancy, but it may also reflect inherent conceptual and measurement problems, and the tendency of broad risk indicators to misclassify organizations because of a weak link with the underlying causal mechanisms for disability or unmeasured confounding factors.

Table VI lists disability prevention and management programs which are either employer- or insurer-based. Such programs may have been designed for one employer only or for a group of employers linked by their liability insurer. This list is rather incomplete because most existing disability management and prevention programs have never been evaluated, and many new ones are currently being developed and implemented. Given this limitation, together with the paucity of high quality studies and a lack of comprehensive cost-effectiveness and cost-benefit analyses, it is currently unclear which programs or program elements are most effective. The available evidence, however, suggests that ergonomic workplace modifications and other worker accommodations play a significant role in reducing work-related disability [Krause et al., 1998a]. Less certain is the contribution of clinical case management and specific medical interventions, because such programs are typically combined with modified work. The only study able to compare occupational and medical interventions in a randomized controlled trial showed no effects for clinical interventions but significant effects for a modified work

TABLE IV. Individual Task Level Physical and Psychosocial Job Characteristics Predicting Duration of Work Disability

Variable	Effect on work disability
Physical job characteristics	
Heavy physical work	Prolonged [Danchin et al., 1982b; Andersson et al., 1983; Ronnevik 1988; Krause et al., 1997b; Dasinger et al., 2000; Høgelund 2000; Krause et al., 2001]
	Phase-specific [MacKenzie et al., 1998]
	No effect [Infante-Rivard and Lortie, 1996]
Repetitive or continuous strain	Prolonged [Bergquist and Larsson, 1977; Krause et al., 1997b]
Musculoskeletal strain	Prolonged [Krause et al., 1997b]
Uncomfortable working position	Prolonged [Krause et al., 1997b]
Crouching	Prolonged [Krause et al., 1997b]
Noise exposure	Prolonged [Krause et al., 1997b]
Bending, twisting, or fixed positions	Prolonged [Bergquist and Larsson, 1977]
More daily hours of physical labor	Prolonged [Lanier and Stockton, 1988]
Construction work	Prolonged [Johnson and Ondrich 1990; Cheadle et al., 1994; Hogg-Johnson et al., 1994; Oleinick et al., 1996; McIntosh et al., 2000]
Work in service sector	Shortened [Maeland and Havik, 1986]
Interaction of physical demands with physical limitations	Prolonged [Yelin, 1986; Yelin et al., 1986]
Interaction of physical demands and place of residence (urban vs. rural)	Prolonged [Maeland and Havik, 1986]
Psychosocial job characteristics	
Exposure to more than one of the following: piece work, time pressure, shift work, heavy physical labor	Prolonged [Karoff et al., 2000]
High job strain or job stress	Prolonged [Maeland and Havik, 1986; Yelin 1986; Theorell et al., 1991; Marklund 1995]
	Phase-specific [Krause et al., 2001]
Low job control	Prolonged [Yelin 1986; Marklund 1995]
	Phase-specific [Krause et al., 2001]
Low control over work–rest-schedule	Prolonged [Kristensen 1991; Infante-Rivard and Lortie 1996]
	Phase-specific [Krause et al., 2001]
High psychological job demands	Prolonged [Marklund, 1995; Krause et al., 1997b; Krause et al., 2001]
Monotonous work	Prolonged [Kristensen 1991]
Long work hours	Prolonged [Krause et al., 1997b]
Low job seniority	Prolonged [Johnson and Ondrich 1990; Tate, 1992b; Dasinger et al., 2000; Krause et al., 2001]
Job dissatisfaction	Prolonged [Bergquist and Larsson 1977; Krause et al., 1997b]
	No effect [MacKenzie et al., 1998; Krause et al., 2001]
Social support	
Low social support at work	No effect [Marklund, 1995]
Low supervisor support	Prolonged [Krause et al., 1997b, 2001]
Low coworker support	Prolonged [Bergquist and Larsson 1977]
	No effect [Krause et al., 2001]
Low practical social support	Prolonged [MacKenzie et al., 1998]

program embracing a participatory ergonomic approach [Loisel et al., 1997]. The effects of communication between physician and patient about work issues (or the lack thereof) are only recently being studied and it appears that such studies need to control for the actual job demands [Dasinger et al., 2001].

Table VII lists society level determinants of RTW including social policy, legislative, and economic factors. Economic factors and social policies clearly influence reporting, administration, and compensation of work-related injuries and illnesses, and especially eligibility for and adequacy of benefits. Their effects on actual duration of

TABLE V. Organizational Level Employer Factors Predicting Duration of Work Disability

Variable	Effect on work disability
People oriented culture	Shortened [Hunt and Habeck, 1993; Amick III et al., 2000]
Proactive in-house RTW program (disability management)	Shortened [Hunt and Habeck, 1993; Nassau 1999; Amick III et al., 2000]
Active safety leadership (safety climate)	Shortened [Hunt and Habeck, 1993; Amick III et al., 2000]
Ergonomic job design practices	Shortened [Amick III et al., 2000]
Unionization	Prolonged [Habeck et al., 1991]
	Phase-specific [Butler et al., 1995]
	No effect [Johnson and Ondrich, 1990]
Large employer size	Shortened [Habeck et al., 1991; Hunt and Habeck, 1993; Cheadle et al., 1994]
	Prolonged [Dasinger et al., 2000; Krause et al., 2001]
	No effect [Hunt and Habeck, 1993; Galizzi and Boden 1996]
Public employer	Shortened [Infante-Rivard and Lortie, 1996]
	Phase-specific [Galizzi and Boden, 1996]
Self-employment	Shortened [Yelin et al., 1980]
	Prolonged [Krause et al., 1997b]

work disability (in contrast to duration of benefits or average system costs) have been less studied. The literature on the effects of wage replacement levels remains controversial despite the fact that this factor has been the topic of many publications. It is beyond the scope of this review to delineate the debates which divide social scientists on this topic, but newer research suggests that interaction effects may be responsible for some of the inconclusiveness of previous research [Bloch and Prins, 2001].

It should also be noted that neither Table VI nor Table VII include studies which describe and compare state- or nation-wide institutions and regulations in the area of disability prevention and management or social welfare, although attempts in this direction have recently been made [Bloch and Prins, 2001]. Neo-liberal policies in some western industrialized countries are bound to reduce the role of the state in providing uniform programs, and, as a result, employers and third party providers will experiment with more varied approaches to disability prevention and management. In other states, experimentation will be facilitated and initiated by state agencies responding to rising disability costs and the prospect of an aging workforce. Although the overall effects of these policy changes are uncertain, the situation provides the opportunity and necessity to rigorously evaluate different approaches to disability prevention and management.

Which risk factors and interventions should be examined?. An important agenda topic for future research is the need for coordinated research efforts, national and international, within and between disciplines, and at different

TABLE VI. Employer- or Insurer-Based Disability Prevention and Disability Management Interventions Predicting Duration of Work Disability

Variable	Effect on work disability
Comprehensive programs including shift of workplace culture, early injury reporting, light duty, rest periods, and on-site physical therapy	Shortened [Fitzler and Berger, 1982, 1983]
Active monitoring of claimants by insurer	Shortened [Leavitt et al., 1972; Donceel et al., 1999]
Orthopedic specialist case management	Shortened [Wiesel et al., 1984; Wiesel et al., 1994]
Early contact of worker by workplace	Shortened [Wood, 1987; Tate, 1992b]
Modified work program	Shortened [Habeck et al., 1991; Crook et al., 1998; Krause et al., 1998a; Bernacki et al., 2000; Høgelund 2000]
Participatory ergonomic program	Shortened [Loisel et al., 1997]
Supported employment	Shortened [Crowther et al., 2001]

TABLE VII. Societal Leval Social Policy, Legislative, and Macro-Economic Factors Predicting Duration of Work Disability

Variable	Effect on work disability
Litigation	Prolonged [Cats-Baril and Frymoyer, 1987; Greenough and Fraser, 1989]
Complexity of compensation system	Prolonged [Tate, 1992b]
High number of job benefits	Shortened [MacKenzie et al., 1998]
High level of wage replacement benefits	Prolonged [Fenn 1981; Worrall and Butler 1985; Butler et al., 1995; Loeser et al., 1995; Meyer et al., 1995; Galizzi and Boden 1996; Campolieti 1999]
	No effect [Yelin, 1986; Høgelund 2000]
	Interaction with job security and benefit networks [Bloch and Prins, 2001]
Dismissal during sick-leave	Prolonged [Høgelund, 2000]
High unemployment rate	No effect [Cheadle et al., 1994; Marklund, 1995; Boden, 1996; Harris, 1997]
Various macro-economic and micro-economic factors	Varying effects [Gardner, 1989; Galizzi and Boden, 1996]

levels of analysis, for systematic progress in different risk factor domains to occur. Broad international cooperation, especially with leading researchers from European countries, should be sought. Given the vast topic to be covered, only the following general and preliminary recommendations can be given for which risk factors and interventions should be examined. These need to be discussed by a wide range of researchers and by those who will use the research results.

(a) Amenability to change. It is necessary to differentiate between two types of predictors: causal risk factors and risk markers or indicators. The latter serve to identify individuals, groups or places at risk, and may constitute factors that cannot be changed (e.g., gender or marital status), whereas the former are amenable to change and provide the basis for interventions. Examples of factors amenable to change include: worker control over amount of work (physical workload) and organization of work tasks (work tempo and scheduling of rest breaks), the availability and type of modified work, help from coworkers, employer accommodations, and local compliance with evidence-based medical care. If there is already a fair body of knowledge on the risk factor (for example, lack of worker control over his/her work and rest schedule), interventions that address the risk factor now need to be developed, and then evaluated. If the effectiveness of an intervention is well established, as for example for modified work programs [Krause et al., 1998a], but implementation is not as widespread as desirable, research should focus on the barriers to implementation and interventions in order to increase uptake. If the costs of an intervention constitute a potential barrier, cost-effectiveness or cost-benefit analyses are needed. If potential beneficiaries of a researched intervention are unaware of it [Hennessey and Muller, 1995], a needs assessment for the dissemination of such results and the development and evaluation of an appropriate research transfer/educational campaign would be the appropriate agenda.

(b) Targeting risk factors and research to the user and setting. Funders and researchers may benefit by organizing risk factor knowledge and related research agendas by "locus of action" (i.e., among the various stakeholders/agents such as employee, employer, health care provider, claims adjuster, disability manager, etc.) or intervention setting (e.g., workplace, health care system, insurance system, regulatory/political bodies) [Krause and Ragland, 1994; Frank et al., 1998]. This will facilitate the alignment of research questions with the practical decision-making needs of various stakeholders.

Stakeholders can be expected to be more motivated to fund and use research on factors they themselves deal with and which they can change or influence. The involvement of stakeholders in the planning and execution of research will also promote transfer of research results into practice (e.g., via the provision of more economic incentives to employers offering modified work).

(c) Generalizability. The generalizability/importance of factors across disability phases, health conditions, and settings/jurisdictions is another useful criterion to identify priority topics for future research. Resources committed to the understanding and modification of factors that are involved in more than one phase of the illness-injury-disability-RTW-process are likely to generate a greater return on investment. Candidate risk factors of this sort include: supportive corporate climate, participatory ergonomics, control over workload, and ability to take unscheduled breaks. Increased control over job tasks and work schedule can be expected to facilitate RTW in almost any setting, for almost any health condition [Karasek and Theorell, 1990; Syme, 1990; Kristensen, 1991; Syme, 1991; Krause et al., 2001].

(d) Evidence from qualitative studies. For the prevention of chronic job-related disability, physical ergonomic factors remain important because of their effect on recurrence risk. However, occupational psychosocial factors are gaining in relevance, including the importance of

supportive employer accommodation and nonadversarial claims processing. Candidate factors should not only be selected based on the existing literature, but also de novo from exploratory qualitative research. For example, focus groups of stakeholders may unearth new candidate factors (see also challenge # 4 "Integration of Cross-disciplinary Research Methods" below).

One focus of qualitative studies should be the identification of new "secondary risk factors" that emerge during the progressive stages of disability and become barriers to RTW during the subacute and chronic phases of disability. The underlying concept of "disability-phase-specific" risk factors [Krause and Ragland, 1994] is discussed in more detail under "Appropriate Design and Analytic Approaches" (Fifth Challenge) below.

(e) Instrument development. When it is widely accepted that a construct is probably causal but is not well measured, better measures need to be developed and pretested in the field. Examples include measures of workplace health and safety culture from organizational psychology, or standardized measures of physical [Torgen, 1999; Wiktorin, 1993, 1996] and psychosocial demands at work [Greiner and Krause, 2000; Landsbergis et al., 2000].

Fourth Challenge: Integration of Cross-Disciplinary Qualitative and Quantitative Research Methods

The direct experience of disabled workers, their families and supervisors, treating physicians, workers' compensation claim adjusters, and disability managers has been underutilized in research on occupational disability and the RTW process. The existing biomedical literature almost totally ignores this potential knowledge base. However, there are a few reports that demonstrate the usefulness of such an approach.

Finnish researchers developed a subjective work ability index based on questionnaire data [Tuomi et al., 1991] which correlates highly with work demands and with clinical assessments of work ability performed by a group of experts specialized in the estimation of work disability [Eskelinen et al., 1991]. The injured worker's self-reported belief about his/her ability to resume work has repeatedly been shown to be an important (non-causal) predictor of RTW [Clancy et al., 1984; Esbjornsson, 1986; Maeland and Havik 1987; Tuomi et al., 1991; Frymoyer 1992; Mondloch et al., 1999a,b]. In general, the validity of self-rated health measures is widely accepted, and global self-perceived health is consistently associated with mortality, functional disability, number of medical diagnoses, and physical as well as mental symptoms [Bjorner et al., 1996]. Many disability researchers evaluating so-called objective tests for functional abilities and disabilities have embraced the notion that valid assessments of disability must include self-reported information from the individual experiencing the disability in daily life [Verbrugge and Jette, 1994]. Although self-rated health and work ability in and of themselves may not be sufficient evidence in legal contexts, they are increasingly becoming the "gold standard" in health-outcomes-oriented health services research and clinical epidemiology (Beaton et al., 1996].

Tapping the personal experience of participants in the RTW-process requires "mixed methods" research. Epidemiologists are increasingly collaborating in RTW research with social scientists trained in the qualitative methods commonly used in cultural anthropology and sociology. These methods range from transcribing in-depth interviews, with subsequent content-analysis, to focus-group and participant-observer methods widely used in participatory action research [Steckler et al., 1992].

Collaborations involving such methods have led to valuable new insights into the *micro-social-process and experience of disablement* from the point of view of various community stakeholders, especially that of the injured/ill workers themselves [Tarasuk and Eakin, 1994, 1995]. Of particular interest are insights gained into the nature of disability after soft tissue injuries, including LBP and repetitive strain injuries [Reid et al., 1991; Borkan et al., 1995].

The strength of these analyses is their depth and the particularly human aspects of work-related disability that they can describe in detail. They may also lead to discrete item-development for questionnaires, which can subsequently be used to verify the importance of a new RTW determinant in a prospective epidemiological study (as in the case of the construct first identified at the Institute for Work and Health in Toronto, "perceived legitimacy of a soft-tissue injury in the eyes of those around the injured worker, as seen by him or her" [Tarasuk and Eakin, 1995; Hogg-Johnson et al., 1998].

Mixed qualitative and quantitative research methods are underutilized in RTW research in general and deserve much more consideration. Special measures are needed to facilitate such interdisciplinary efforts (which do *not* tend to arise naturally from university-based research). Future RTW research funding needs to explicitly reward interdisciplinary teams of researchers and provide incentives for the submission of proposals by such "mixed-methods" consortia in the RFP process.

Fifth Challenge: Appropriate Design and Analytic Approaches

Need for a minimum methodological standard. In the case of quantitative studies designed to estimate the impact of various risk factors on RTW, it is advisable that future

studies meet a number of methodological standards. Given the multifactorial nature of the RTW process, multivariate statistical methods are critical if future studies are to accurately estimate the independent and combined contributions of the many risk factors involved. Ideally, a study should at least include measurement of a few risk factors from each of the seven domains listed in Tables I–VII that have variance in the study setting. It is also important to explore interaction effects in such multivariate models. While currently lacking from many publications of multivariate analyses, explicit information on how the final model was arrived at, whether formal tests of goodness-of-fit were satisfactory, and how potential problems, such as influential data points and collinearity, were dealt with, needs to be provided.

Prospective designs with repeat measures of risk factors are essential, although creative analyses of these data sets might include case-control or case-cohort strategies. "Prospective" in this context means that time-varying risk factors such as questionnaire responses or clinical findings are collected prior to outcome occurrence. A key rationale for this standard is that the disablement process is developmental in nature and unfolds dynamically over time [Krause and Ragland, 1994; Verbrugge and Jette, 1994]. Good evidence for this assertion is now available from phase-specific analyses (see below).

Outcomes that are also time-varying, such as functional status, pain, and health-related quality-of-life, are optimal when measured repeatedly, as disability changes in subjects who have returned to work and in those who have not. When such outcomes are combined with RTW data, a balanced understanding of the extent to which RTW corresponds to symptom resolution and functional recovery is achieved. This is essential for understanding the basis of recurrences, which may sometimes relate to premature RTW.

For relatively uncommon events such as chronic disabling LBP, sample size for RTW studies can be onerous (typically 5–10%, in most cohorts of injured workers, have more than 6 months of work disability). Less demanding sample sizes are required if one focuses only on later stages of disability, e.g., the determinants of chronicity amongst subjects who are all in the subacute stage upon accrual. In short, inception cohorts are not always the most efficient design, unless acute-stage determinants of disability must be studied.

With respect to intervention studies, it is often not feasible to randomize individual subjects to interventions which can only be efficiently delivered to entire populations (e.g., modified work programs in a workplace or jurisdictional-level workers' compensation policies). This is well recognized in other fields of public health, where the value of quasi-experimental designs is thoroughly established (e.g., early municipal water fluoridation trials, and more recent community intervention trials to prevent coronary heart disease). It is laudable that some investigators have performed randomization of entire companies; Loisel, in a landmark study, accomplished this for 32 firms across four treatment arms [Loisel et al., 1997]. However, even with this extraordinary effort, the numbers of firms in each arm were insufficient to achieve confounder balance for key variables, especially those at the firm level. Since firm-level variables are widely thought to be critical in RTW [Frank et al., 1998], the advantages of "cluster-randomization" at the firm level are therefore dubious in this context. Quasi-experimental designs, such as staggered time-series, where various workplaces receive the intervention at intervals with pre- and post-measures in each, can go a long way toward controlling for a full range of confounders, and are much more likely to be acceptable to participating companies, local insurers, or regulatory bodies. In all such designs, it is desirable to have one group of subjects maintain "control" status for as long as possible in order to control for secular trends in either risk factors or outcomes. A novel suggestion is the use of "job-matched" controls, which have been successfully used in an etiological study of LBP at work [Kerr et al.,] and in a recent wage-loss study of permanently disabled workers [Peterson et al., 1997; Reville, 1999].

The importance of disability phase-specificity. Another recommendation for further research is to take the disability phase-specificity of risk factors and interventions into account, during both the design and analysis stages of a study. "Phase specificity" refers to the fact that the impact of risk factors (or interventions) may vary across different phases of the disablement process [Krause and Ragland, 1994; Dasinger et al., 2000; Krause et al., 2001]. Research designs and analytic strategies not accounting for this phenomenon may be unable to detect risk factors which are predominantly associated with only certain phases of the disabling process. In fact, the failure to stratify analyses according to work disability phase may lead to the masking of important risk factor effects [Oleinick et al., 1996]. Similarly, intervention researchers should recognize that suboptimal timing of interventions may be responsible for disappointing results [Sinclair et al., 1997; Frank et al., 1998].

Disability phases can be defined by duration of work disability, along a temporal continuum since the date of injury [Krause and Ragland, 1994]. While individual studies may choose different cut-points between phases, the differentiation of an acute phase (up to 30 days of work disability], subacute (30–90 days), and chronic disability (more than 90 days) is becoming widely used. The concept of phase-specificity was originally developed for the study of occupational disability due to LBP [Spitzer et al., 1987; Krause 1993; Krause and Ragland, 1994; Von Korff, 1994], but its usefulness has since been empirically demonstrated not only for spinal disorders [Frymoyer et al.,

1985; Hogg-Johnson et al., 1994; Frank et al., 1996; Frank et al., 1998; Williams et al., 1998; van der Weide et al., 1999a; Dasinger et al., 2000; McIntosh et al., 2000; Krause et al., 2001] but also for other injuries and illnesses [Rael, 1992; Galizzi and Boden, 1996; Oleinick et al., 1996].

In analytical statistical terms, phase-specificity reflects the time-dependence of effects of certain predictor variables as well as the time-dependent variation in type and level of predictor variables affecting outcome. Prognostic models should consider the fact that some predictors occur de novo after baseline (e.g., litigation), change during the course of disability (e.g., mental health), and, though unchanged, may exert a different impact at different phases (e.g., injury severity) or reverse the direction of their effect (e.g., pre-injury wage). It is necessary to employ appropriate analytic techniques to handle these complexities. These are discussed next.

Recommended analytic tools. The fundamental analytical tool for both epidemiological and economic RTW research has been survival analyses by multiple regression methods of two basic kinds, semiparametric (Cox proportional hazards) and parametric (e.g., Weibull, gamma, log-logistic, etc.). Both families of methods are capable of dealing with the usual censoring in time-on-benefits or time-to-return-to-work data [Collett, 1994]. As mentioned above, a number of studies have found profound time-dependence of effects on RTW outcome. Both families of methods can be adapted to deal with this complexity, as well as with predictor variables which change their impact during follow-up [Dasinger et al., 2000; Krause et al., 2001].

For health-outcomes which are quasi-continuous, such as pain or functional status scales or indices of health-related-quality-of-life, repeat measures necessitate the use of regression methods which adjust for the nonindependence of measurements on the same individual over time such as general estimating equation models [Liang and Zeger, 1993].

While it is sometimes important to analyze a dichotomous outcome, for e.g., receipt of a permanent disability award, it should be recognized that sample size requirements are more demanding when such events are uncommon. The extra time-to-event information introduced in survival analysis typically allows the use of smaller sample sizes.

Predictors of RTW originate from several levels, from the "individual level" to the "societal level" (see Tables I–VII). These levels interact with each other in many ways, and models of disability eventually need to describe these interactions qualitatively and quantitatively. Analytic methods to approach such complex relationships include, for example, path analyses and structural equation modeling for multi-*step* processes as well as hierarchical regression modeling for multi-*level* analyses [Diez-Roux, 1998]. However, the quantitative modeling of complex hierarchical models and multistage structural equations may be premature, as long as theory remains underdeveloped, relevant variables on each level/stage are not well understood, and valid and reliable measurement instruments have not been developed. Moreover, advanced, multilevel study designs need to tap different data sources to span domains/levels and to combine primary data collection with accessing and merging routinely collected data, often from administrative systems. For obvious logistic reasons, the use of such comprehensive designs in RTW research is a largely unattainable ideal at this moment.

Proximate risk factors, i.e., those factors related to the affected individuals' interaction with their immediate environment, can be examined even with basic study designs. The value of the study of more distal factors, i.e., societal or macro-economic factors, will depend on a better developed body of knowledge of more proximate or intermediary factors through which these more distal factors tend to exert their influence. For example, several studies report an association between higher wage replacement rates and delayed RTW [Gardner, 1989]. The commonly offered interpretation is that lower benefit levels act as economic incentives for the injured worker's decision/behavior to return to work earlier. However, considering that (a) benefit amounts are well below pre-injury wages [Peterson et al., 1997; Reville,1999], (b) actual disbursements (and alternative income) are usually unpredictable for the worker at the outset, and (c) the worker's decision-making process has not been well studied, the exact role of this factor is not so clear. In fact, several alternative explanations of the apparent statistical association between wage replacement rates and RTW have been offered (e.g., confounding by the heaviness and inflexibility of work, interaction with job security) and warrant further inquiry [Yelin et al., 1986, Yelin 1989; Galizzi and Boden, 1996; Bloch and Prins, 2001] The need for a theory of worker responses including a life cycle approach has been suggested by Gardner in his extensive 1989 review of the economic literature, but little progress has been made in this direction. Future research needs to include primary data collection yielding more immediate responses from workers, family members, employers, and providers. However, it is difficult and time-consuming to obtain confidential data on individual cases from health care providers or insurers, even with the patient's consent. Special care needs to be taken to protect confidentiality and the status of open claims. A prospective design with adequate power to predict relatively uncommon events such as chronic disability requires the enrollment of large numbers of providers, employers, and patients prior to disability development and RTW. Interviewing providers, supervisors, or injured workers themselves is also problematic, because it constitutes an uncontrolled intervention with unpredictable effects.

Clearly, considerable resources, experience, flexibility, and creativity are required for innovative studies using primary data collection methods.

CONCLUSIONS

Despite shortcomings in the current research on RTW, there is much room for optimism. Regarding the first challenge, the selection of appropriate outcomes and databases in RTW research, a consensus seems to be emerging. More and more researchers appear interested in combining primary data from injured worker and stakeholder interviews with secondary administrative databases. These combined data sets enrich our understanding of the full range of risk factors for delayed RTW, as well as the full burden of health, social and economic consequences of occupational illness and injury.

Significant progress has already been seen in recent years in meeting the second challenge, in that more studies are being done by interdiscipilinary research teams. However, more incentives need to be offered for the submission of research proposals that span the relevant disciplines, particularly the social/behavioral, biomedical, and policy-analytic sciences. It is particularly important to develop some explicit theory to determine RTW, to which a number of these disciplines need to contribute.

With respect to the third challenge, concerning the extraordinarily diverse set of risk factors thought to determine RTW outcomes, the time is ripe for prioritizing research via issuing RFPs for studies on specific domains of risk factors meeting the five selection criteria outlined: amenability to change, relevance to users of research, generalizability across health conditions, disability phases, and settings, "degree of promise" as derived from qualitative exploratory studies, and capacity to improve measurement instruments.

Integrating cross-disciplinary research methods, the fourth challenge, also gives cause for optimism. There are increasing numbers of published reports in which qualitative and quantitative methods have played complimentary roles. What remains is to provide incentives from funding agencies for more "mixed methods" research, and to better integrate the training programs of the disciplines involved.

Lastly, in addressing the fifth challenge of appropriate design and analytic methods, there is an upward trend in the methodological quality of studies being published. We urge journal editors and peer reviewers to uphold widely accepted standards for the design and analysis of natural history studies, while at the same time keeping an open mind concerning appropriate methods for evaluating the impact of group-level interventions such as those deployed in workplaces or entire insurance systems. Adherence to the clinical-epidemiological beliefs in the inherent superiority of the randomized control trial will be unhelpful here, with improved quasi-experimental designs holding much promise.

In summary, there are challenges to insure that RTW research is both of high quality and relevant to the practical issues facing injured workers, health care professionals, employers, insurers, and regulators. A concerted effort on the part of research funders, research users, and researchers themselves can meet these challenges.

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